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Current Anesthesia Recommendations for Companion Birds

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Introduction

Avian anesthesia is becoming more commonplace in clinical practice. To successfully provide chemical restraint and anesthesia for avian patients, one needs to recognize their unique anatomic and physiologic differences. These differences often impact intraoperative management and monitoring. Once an understanding of their differences is achieved, anesthesia can be performed with few complications. There are several differences between avian and mammalian anesthesia that require the avian anesthetist to be more attentive. If the anesthetist is conscientious and has a well planned protocol then all avian anesthetic events can be successful. Many practitioners are performing anesthesia on several avian species including wildlife, game birds and companion birds. Most of the information and situations that will be discussed will be concerning companion avian patients.

Anatomy

Differences between avian and mammalian anatomy can impact the effectiveness of anesthesia. The avian trachea courses to the right of the esophagus and then under the crop at the thoracic inlet. After passing the thoracic inlet, it then combines with the syrinx (similar to mammalian larynx) and divides into the primary bronchi. The anatomy of the trachea varies with different avian species. For instance, the trachea of the whooping crane extends to the cloaca then doubles back and returns to the thoracic inlet before connecting with the syrinx. Other species of cranes have their trachea imbedded in the sternum, where as the Helmeted Curassow has a trachea that courses subcutaneously outside the confines of the sternum.¹ The avian

trachea is longer and has a larger diameter than small mammals of comparative size. Despite their differences, all birds have tracheal cartilages that form complete rings and the avian trachea is lined with pseudostratified or simple columnar epithelium.

The respiratory system has two distinct functional components: one for ventilation and one for gas exchange. The ventilation component is composed of the conducting airways (trachea and bronchi), air sacs, thoracic skeleton and muscles of respiration. The trachea bifurcates into the primary bronchi which extend into the secondary bronchi and which further extend into the tertiary bronchi, also known as the parabronchi. Each primary bronchus enters the avian lung, travels to its surface and then turns caudally to an opening into the abdominal air sacs. Most birds have nine air sacs, four paired and one unpaired. The four paired air sacs include the cervical, cranial and caudal thoracic, and abdominal. The unpaired air sac is the clavicular air sac which is located dorsal and caudal to the crop. Air sacs do not contribute significantly to gas exchange because they are relatively avascular. The sacs near the lungs are lined with cuboidal and columnar ciliated epithelium, unlike the sacs distal from the lungs which are lined with a single layer of simple squamous epithelium.^{1,2}

The gas exchange component of the avian respiratory system is the parabronchial lung. The parabronchi (tertiary bronchi) have shallow depressions (atria) that are evenly displayed along their walls. Each depression has three to six funnel-shaped ducts (infundibula) which lead to air capillaries that form an anastomosing network with blood capillaries for gas exchange.^{1,2}

Physiology

Unlike mammals, birds do not have a diaphragm, therefore breathing (inspiration and expiration) is an active process requiring muscular activity. Inspiration occurs when the

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inspiratory muscles (external intercostals) contract causing the pressure within the air sacs to decrease below atmospheric pressure and allowing air to flow into the respiratory system. During inspiration 50% of the inspired air enters the lung and cranial air sacs while the other 50% enters the caudal air sacs. When the expiratory muscles (internal intercostals and abdominal) contract, air that was in the caudal air sacs move into the lung while the air in the lungs and cranial air sacs move out the trachea.¹

Birds have many of the same physiologic components for respiratory control as mammals. These components include a central respiratory pattern generator, central chemoreceptors that are sensitive to the partial pressures of carbon dioxide, and many similar peripheral chemoreceptors. Birds also have a unique group of peripheral receptors located in the lung, called intrapulmonary chemoreceptors, that are acutely sensitive to carbon dioxide and are insensitive to hypoxia.³

The avian respiratory system is quite efficient despite the long, large trachea of many birds. The fully conscious, healthy, unmedicated bird can compensate for the larger tracheal dead space by having a relatively low respiratory frequency (approximately one-third that of mammals) that decreases the impact of the larger tracheal dead space volume on ventilation. Therefore, minute tracheal ventilation is about 1.5 to 1.9 times that of mammals.² The avian air sacs increase efficiency by allowing fresh air to enter the lungs on both inspiration and expiration. Since birds do not have alveoli, air capillaries function as the anatomic location of gas exchange. Lung capacity of birds is lower than their mammalian counterparts; however, because of air sacs the total respiratory volume is greater. The efficiency of gas exchange in the avian lung is excellent because the blood/gas barrier is not as thick as in mammals. The air capillaries are arranged perpendicular to the interperibronchial arteries. The degree of oxygen and carbon dioxide exchange at the capillaries depends on where and for what distance the blood contacts the blood/gas interface.²

The efficiency of the avian respiratory system can be severely compromised during anesthesia. The position of the bird during anesthesia can significantly affect ventilation.

For instance, by positioning the bird on its back ventilation is significantly reduced because of the weight of the abdominal organs on the lungs and air sacs, thus reducing their effective volume. General anesthesia can also affect ventilation by decreasing inspiratory and expiratory muscle activity. Some common health conditions that can also affect ventilation and thus anesthetic success include obesity, liver disease, egg peritonitis, and any abdominal mass.^{3,4}

Pre-anesthetic Considerations

Patient. The health of the bird should always be considered before doing anesthesia. Many birds with compromised health do not survive anesthesia. Therefore, pre-anesthetic evaluation is highly recommended to detect and correct any underlying disease prior to inducing anesthesia. Some cases may require supportive care for days or weeks in order to adequately stabilize a compromised patient. The ideal minimum database for an avian patient includes thorough history, physical exam, platelet count, LDH, AST, UA, fecal, Gram stain parasite check, PCV, TP, WBC with differential and bile acids.⁴

Fluid and nutritional therapies may be required to stabilize a patient before anesthetic induction. The conventional methods of evaluating hydration in a dog or cat is difficult and often not accurate in birds. Most avian patients suffering from trauma or disease can be assumed to be at least 10% dehydrated. The following equation can be used to calculate the bird's fluid requirements:

$$\begin{array}{r} \text{normal body weight (grams)} \\ \times 0.1 \text{ (10\% dehydration)} \\ \hline = \text{fluid deficit in milliliters} \end{array}$$

Dose for maintenance fluids is estimated at 50ml/kg/day.

Many diseased pet birds needing anesthesia are on all-seed diets and should be put on nutritional therapy prior to anesthesia. If the situation is not an emergency, try to get the bird converted over to a pelleted diet for at least a couple of weeks. Once the health of the bird has been evaluated, a risk assessment can be allocated (see Figure 1). Risk assess-

Class I	Young, healthy patient, undergoing elective procedure
Class II	Young, healthy patient, undergoing non-elective procedure, or healthy patient undergoing elective procedure
Class III	Patient with an ongoing health problem undergoing any procedure
Class IV	Patient with a major, unstable health problem undergoing a procedure
Class V	Emergency to save patient's life

Figure 1: Risk assessment values. Source: Ritchie B, Harrison G, Harrison L. *Avian Medicine: Principles and Applications*. Lake Worth, FL: Wingers Publishing. 1994; p. 1075.

ment allows one to estimate the duration of safe anesthesia. Most avian patients needing surgical procedures are not Class 1 but instead Class 4 and 5. With careful supportive care, a clinician can decrease the anesthetic risk from 4&5 to 2&3.⁴

Fasting. Fasting is recommended to decrease the likelihood of regurgitation and aspiration of food. Birds will not show signs of dyspnea when they aspirate. Therefore, it is especially important to empty the crop of its fluid contents which are easily refluxed during general anesthesia or recovery. If unable to wait for the crop to empty, then the crop can be aspirated by using a syringe and feeding tube. Fasting recommendations vary depending on the source that is consulted. But the most widely accepted rule is overnight for large birds and 1-3 hours for small birds. Hypoglycemia is a concern for the small birds due to their high metabolic rate. Therefore, for small passerines such as finches and canaries, or immature birds of larger species, a fast should not exceed 1 hour. Water should be available until approximately 1 hour before anesthesia in most species.^{4,5,6,7}

Planning. The type of procedure to be performed on the patient can often determine how anesthesia will be induced. For instance, if the patient is having an oral procedure then tracheal intubation may not be ideal. If a fracture reduction is going to be performed, one needs to remember that the long bones are pneumatic and can decrease the anesthetists ability to maintain a surgical plane of anesthesia. This will also increase environmental exposure of the inhalant. Having a planned protocol is important in avian anesthesia. Many times situations happen where instant action can make the difference between life and death. It is always recommended to anticipate problems and have all of your necessary equipment and emergency drugs readily available.

Equipment. The equipment required for avian anesthesia depends on the method of induction that is chosen. If inhalant anesthesia is to be used, then the following equipment is recommended: valveless, non-rebreathing circuit (Bain circuit), anesthesia machine with an out-of-circuit precision vaporizer for isoflurane, standard 0.5L resevoir bag can be used but better control and monitoring of respiration can be achieved with a smaller volume bag designed for birds or handmade bags from plastic bags (disposable and inexpensive), proper scavenging system, proper sized endotracheal tubes, and face masks.⁴

Anesthetics

Injectables. Injectable anesthetics are not recommended for use in companion avian practice. Unexplained deaths are often associated with injectable anesthesia. However, research has been done that suggests its effectiveness in wild and ratite species. The advantages of using injectable anesthetics include ease of use in the field, minimal need for technical equipment, availability, ease of administration, rapid induction and relatively low cost. Disadvantages include elimination that is dependent on biotransformation and excretion, dose-dependent cardiopulmonary depression, potentially difficult reversal of drug effects in an emergency situation, potentially prolonged and violent recoveries, and lack of adequate muscle relaxation with some drugs.⁷ There is a tremendous variability in therapeutic dosages and physiologic effects, both at the species and individual patient levels. Many do not provide an adequate plane of anesthesia without reaching tissue levels that threaten the life of the patient. Stable, uncomplicated levels of anesthesia are difficult to produce. Since most drugs used for injectable anesthesia have a narrow therapeutic index and the species and individual dose responses vary widely, clinicians are advised

to start at the lower end of the dosage range with the following drugs.

Ketamine - Dissociative anesthetic that produces good somatic analgesia but poor visceral analgesia and therefore does not provide adequate analgesia for major surgical procedures. Muscle relaxation is poor; therefore it is recommended that ketamine be used in combination with a muscle relaxant. It is partially excitatory in the central nervous system (CNS) which may account for its poor muscle relaxation quality. This drug has a highly variable effect in different avian species. In mammals, ketamine is metabolized by the liver and excreted by the kidneys. No studies have been performed to look at its metabolism in birds. May be administered intramuscularly (IM) or intravenously (IV) at a dose of 10-30 mg/kg. First signs of incoordination should occur within three to five minutes. Smaller species require slightly higher doses. The typical duration of anesthesia is 10-30 minutes, and recovery, which is completely dose-dependent, may take several hours. Recoveries with ketamine have been characterized as violent and stormy. For this reason, it is often combined with xylazine or diazepam. Depending on the dose, these combinations produce restraint to light surgical plane anesthesia. The combinations also provide muscle relaxation and sedation. The ratio for both ketamine/diazepam or ketamine/xylazine combination is 10:1 on a mg/kg basis. This combination is considered to have a wide margin of safety, but the xylazine does provide a dose-related respiratory depressant effect and bradycardia. Onset of action is usually 3-5 minutes after intramuscular (IM) administration or 1-3 minutes after intravenous (IV) administration.^{4,7,8,9}

Xylazine - Alpha-2 adrenergic agonist that provides good skeletal muscle relaxation. Improves anesthetic recovery and provides sedation and analgesia when used in combination with ketamine. May be injected IM, IV, or subcutaneously. Adverse effects include deregulation of the thermoregulation center in the hypothalamus. If ambient temperature is low it produces hypothermia. If ambient temperature is high it produces hyperthermia. This drug also has potent cardiopulmonary-depressive effects which are not compensated by the effects of ketamine. Another disadvantage of using this combination with ketamine

is that recovery periods may extend for 4 or more hours when administering large enough doses to produce a deep plane of anesthesia suitable for neurosurgery.^{8,10}

Propofol - Known for rapid onset of action and smooth inductions. Duration of anesthesia is very short in dogs (2 minutes). Propofol is often used in small animal anesthesia for short procedures or prior to inhalant anesthesia. Recoveries are quick because of rapid metabolism. It is safe to use in head trauma patients because it decreases cerebral blood flow and cerebral oxygen consumption. Adverse effects include direct myocardial depression, peripheral vasodilation and venodilation causing blood pressure and cardiac output to decrease. Apnea is common after a rapid, intravenous bolus.⁸ A study done with chickens showed that induction and maintenance with propofol caused significant respiratory and cardiovascular depression. A dose of 4.5-9.7mg/kg was given IV as a bolus for induction and the chickens were maintained on a constant infusion of 0.5-1.2 mg/kg for 20 minutes. Hypoxemia was also common and when used at 3 times the induction dose, propofol was fatal to all of the chickens. In this study, it was concluded that propofol has a narrow margin of safety in birds and is not recommended for use in pet birds.¹¹ Another study showed that propofol used for induction and maintenance in a barn owl was effective and safe. Anesthesia was induced with 4mg/kg IV and maintained with 0.5mg/kg/min IV.¹² More research is warranted with this drug.

Diazepam - Water insoluble benzodiazepine that provides good muscle relaxation, tranquilization, and anticonvulsant. Intramuscular injections are slowly absorbed. Benzodiazepines have been recommended for use with ketamine because they produce minimal adverse cardiopulmonary effects.

Yohimbine - Competitive alpha-2 adrenoceptor antagonist. This drug is used to reverse the sedative and respiratory-depressant effects of xylazine. Yohimbine can cause CNS stimulation, increased heart rate, and increased blood pressure. A study using yohimbine to reverse the effects of ketamine/xylazine in budgerigars showed that the optimal dose of yohimbine for reversing the dose of ketamine/xylazine appears to be within the range of 0.11-0.275mg/kg, which is 100%-250% of the manufacturer's suggested dose

for reversing xylazine in dogs. The authors of the study recommend using 0.275mg/kg IM as an effective reversing agent in the budgerigar.¹⁰ Keep in mind that IM administration is slow and is not recommended in an emergency.

When an intravenous route is used, the potential for severe cardiopulmonary depression may be minimized by administering injectable agents in multiple small boluses or as an infusion. Current recommendations are that injectable anesthetics be used in pet birds only when an inhalant anesthetic, particularly isoflurane, is unavailable.

Inhalant Anesthesia. Historically, ether, methoxyflurane, halothane, and isoflurane have been used for inhalant anesthesia in birds. When compared to injectable anesthetics, inhalation agents have numerous advantages. They can be titrated to effect, have a more consistent therapeutic index, provide rapid induction and smooth, rapid recoveries. Of the following agents discussed, isoflurane is currently the preferred choice.

Isoflurane - The inhalant most widely used in practice for general avian anesthesia. Isoflurane is the least soluble of the three agents listed with a blood/gas coefficient of 1.4 compared to 2.3 for halothane and 12 for methoxyflurane. This allows very rapid induction and recovery, as well as the capability of achieving very rapid changes in anesthetic level. It has a high margin of safety for both the patient and hospital staff, reduced arrhythmogenic properties, reduced cardiovascular depression and reduced respiratory depression. Isoflurane provides good analgesia and adequate muscle relaxation. It is also a stable agent, making it resistant to metabolic breakdown. Therefore, it has a higher level of safety in those patients with compromised liver or kidney function. At sedative and light surgical planes of anesthesia, adverse cardiopulmonary effects are minimal; therefore, this drug also can be safely used to obtain diagnostic information from high-risk and critically ill birds. Isoflurane has a larger time interval between apnea and cardiac arrest than the other agents mentioned. It has been clinically proven to be a safe and effective anesthetic agent.^{4,6,7,8,9,13}

Halothane - This is a very potent inhalant anesthetic. It provides rapid induction (2-3 min) and recovery, although not as rapid as

isoflurane. Cardiovascular effects include a progressive decrease in cardiac output, stroke volume, and arterial blood pressure. It also sensitizes the myocardium to catecholamines which will lead to premature ventricular contractions, ventricular tachycardia or fibrillation. At surgical levels, halothane provides good muscle relaxation; however, at these levels birds will experience pronounced respiratory depression. The time frame between apnea and cardiac arrest is seconds.^{3,6,8,13}

Methoxyflurane - This drug has a very low vapor pressure and is potent. It has analgesic effects at subanesthetic doses. It is highly soluble in blood which prolongs induction and recovery. Practitioners have reported that recovery can take up to hours. The solubility also prevents the ability to change anesthetic depth rapidly. Cardiovascular effects include reduced myocardial contractility and peripheral vasculature dilation which leads to reduced cardiac output and blood pressure. Methoxyflurane also sensitizes the myocardium to catecholamines. Opinion holds that this is an extremely dangerous method of providing anesthesia in birds, and if an adequate oxygen supply is not assured, it will result in rapid death of the patient. As with halothane, the time from apnea to cardiac arrest is nearly immediate.^{4,8,13}

Practitioners believe that the ideal avian anesthetic agent is one that creates minimal stress in administration, has a high therapeutic index, provides rapid induction and recovery, induces minimal physiologic changes, provides adequate restraint for the desired procedure and can be safely used in critical cases.⁴ It appears that isoflurane is currently the closest example of the ideal avian anesthetic.

Induction

Anesthesia induction with isoflurane can be achieved by physically restraining the patient and placing a mask over the beak and nares. Most small animal masks do not fit avian patients, resulting in dilution of the anesthetic gas with room air. For birds that weigh less than 150gm, an effective mask can be made by covering the end of a 12cc syringe case with a section of latex glove. The syringe case can then be slipped over an Ayres T-piece with a 50ml anesthesia non-rebreathing bag. A cat-

sized mask may be modified by stretching a finger from a latex exam glove over the cone and cutting the tip of the finger to open a small hole. A plastic drinking cup can also be used by placing it over the birds beak and placing soft paper products between the cup and the patient's neck to prevent gas leaks. Some of these modifications are disposable and therefore minimize nosocomial infections. The box or tank systems are usually not recommended for inducing anesthesia in birds because it is difficult to monitor the patient, however, if the bird is extremely stressed when being physically restrained it might be better to use the tank or box system to alleviate stress. Some clinicians will use propofol to induce patients, but it could be more stressful to inject intravenous drugs than it would be to mask down the patient.^{4,7,9}

Tracheal intubation. After induction, any patient that will be anesthetized for more than 10 minutes should be intubated with an appropriately sized endotracheal tube. Since birds have complete tracheal rings, it is recommended to use non-cuffed endotracheal tubes. However, a non-cuffed endotracheal tube does not provide a sealed airway for protection against aspiration of secretions or refluxed gastrointestinal contents. Some recommend using a cuffed tube but to carefully inflate it just enough to prevent leakage when 10-15 cm water pressure is applied to the airway. If the cuff is over-inflated it could cause longitudinal fissures in the trachea. For most birds 350gm or larger, a 3mm cuffed tube will work well. For small birds a non-cuffed tube or large gauge IV catheters may be effective. Red-rubber feeding tubes have also been reported to work well as a modified endotracheal tube by cutting off the end and fitting it to an adaptor. One should be aware that the catheter sized tubes will not provide a sealed airway and may easily become plugged with secretions, mucus, or blood. Airway patency should be checked regularly during general anesthesia. Some prefer using Murphy tubes because they have side openings as well as an end opening which could decrease the chance of mucus occlusion. For birds less than 100gm it might be best to maintain them with a mask. Most recommend the oxygen flow rate should be at 500cc/min with the isoflurane at 5% for the initial mask down. It should take less than a minute for induction and then the isoflurane

should be reduced to 1-2%. Maintenance may be as low as 0.25% for some birds. When inducing birds in this way, one needs to be aware that birds can achieve a deep level of anesthesia quickly; therefore, constant monitoring is recommended. An ideal anesthetic level is achieved when the eyes are closed, pupillary light response is delayed, the nictitating membrane moves slowly over the cornea, and muscle relaxation is apparent.^{4,6,7,9,13}

Air Sac Intubation. If tracheal intubation is not possible, then air sacs can be used effectively as an alternative site for intubation. Anesthesia can be delivered by placing a short endotracheal or red rubber tube into the abdominal or caudal thoracic air sacs. Placement is rapid and may be indicated in emergency cases when the animal is presented with respiratory arrest or severe dyspnea due to a foreign body or aspiration. Studies indicate that isoflurane can be safely administered through air sacs to maintain surgical anesthesia. When placing an air sac tube, use sterile technique to prevent life-threatening air sacculitis. A skin incision is made just behind the last rib in the dorsal paralumbar area, then the abdomen is entered bluntly with a curved mosquito hemostat. The tubing is inserted cranially to a point where condensation can be seen in the tube as the bird exhales. It is then sutured into place. The anesthetic machine can then be hooked up to the endotracheal tube and anesthesia can be successfully maintained for up to one half an hour. To maintain the patient at a surgical level, the oxygen and isoflurane flow rates may need to be higher than if tracheal intubation was used. This may induce apnea and the anesthetist should be aware of that possibility.^{4,6,9}

Intraosseous Cannulation. A third method of induction is by intraosseous cannulation. This is not a common technique and not normally recommended. It was studied as a method of induction using injectable anesthesia. This particular study concluded that the intraosseous route was effective for the administration of drugs that induce chemical restraint.¹⁴

Fluids. After induction, fluids should be administered for those procedures that are going to be longer than 15 minutes. The fluids administered should be heated to 96°F to minimize hypothermia. Administer carefully

to avoid fluid overload. Maximum acute fluid load that can be tolerated by a healthy patient is 90ml/kg/hr. In an average sized cockatiel, this would be a maximum of 9ml/hr or 0.15ml/min. If a patient is dehydrated or critically ill, the electrolyte and acid/base levels are unknown and the bicarbonate deficit cannot be calculated, then administration of 1mEq/kg of bicarbonate at 15 to 30 minute intervals to a maximum of 4 mEq is recommended. Daily fluid requirement in resting birds is estimated to be 40-60 ml/kg/day. Dehydration should be corrected with $\frac{1}{4}$ to $\frac{1}{2}$ of the calculated fluid deficit in the first 4 to 6 hours with the remaining volume administered over the following 24 hours. Healthy, anesthetized birds should receive replacement fluids at a rate 10ml/kg/hr for the first 2 hours, and then 5-8ml/kg/hr to prevent over-hydration. Jugular, cutaneous ulnar, and medial metatarsal veins are common sites for IV access^{4,7}

Monitoring

Respiration. When the patient is fully induced and prepared for surgery, attentive monitoring is required. The respiratory rate and depth is best monitored by direct visualization. It can also be monitored with an electronic thermistor device placed in line with the endotracheal tube. It will give an audible signal whenever the patient exhales. It is recommended to get an estimation of the bird's normal ventilatory depth and rate before anesthesia so that anesthetized levels can be compared to normal unanesthetized levels. If the rate increases it could be due to one of the following things: light plane of anesthesia or difficulty breathing because of pressure on the respiratory muscles. Apnea induced death in avian patients is common during surgical procedures. This is often due to an increase in PaO₂. Studies have shown that high fractions of inspired oxygen (FIO₂) may contribute significantly to ventilatory depression by depressing the normal activity of O₂-sensitive chemoreceptors, resulting in a lessened ventilatory drive. Both respiratory rate and tidal volume decrease as the FIO₂ increases.^{2,3} Artificial ventilation is highly recommended for avian anesthesia because of the relationship between apnea and cardiac arrest. As mentioned previ-

ously, isoflurane is the safest anesthetic agent with the longest apnea to cardiac arrest period (a few minutes). Respiratory pauses longer than 10-15 seconds should be treated by lightening the plane of anesthesia and by increasing the rate of assisted ventilations or initiating mechanical ventilation. When manually ventilating, the airway pressure should not exceed 15-20 cm H₂O pressure to prevent barotrauma to the air sacs.

Heart Rate. During anesthesia the heart rate is best evaluated by direct auscultation over the breast muscle. A general rule of thumb goes as follows, if the heart rate is easy to count then it is too slow. Normal heart rates can be found in Figure 2. Direct auscultation may be difficult if the patient is draped off for surgery. This situation may require an esophageal stethoscope. Stethoscopes with pediatric tubing can be used in birds the size of Amazons and larger. Electrocardiogram is an excellent way to measure the heart rate. If anesthesia is too deep, the T-waves will become smaller and eventually disappear. As the depth further increases, the R-waves will increase in magnitude and S-waves will decrease.⁴

Heat Loss. Physiologically, birds are less efficient in regulating their body temperature than mammals and as a result, undergo rapid changes in body temperature during anesthesia. Loss of heat during surgical anesthesia can significantly affect anesthetic recovery and survival. To minimize heat loss, methods such as circulating water blankets, warming up intravenous fluids, and reducing the amount of alcohol used during preparation can be implemented. Saline is a good substitute for alcohol during patient preparation. The rectal temperature normally ranges between 105-107°F. A reduction in temperature can predispose the patient to cardiac arrhythmias. Traditional thermometers require cloacal in-

Species	Beats/Min.	Breaths/Min.
Budgerigar	600-750	55-75
Cockatiel	450-604	30-40
Parrot	120-780	10-20
Ostriches	60-72	2-20

Figure 2: Normal avian respiratory and heart rates. Source: Ritchie B, Harrison G, Harrison L. *Avian Medicine: Principles and Applications*. Lake Worth, FL: Wingers Publishing. 1994; p. 1077.

sertion and take three to five minutes for an accurate reading. Another option is a tympanic scanner, which gives a reading in five to six seconds. The monitors are easy to use by applying the probe to the outer surface of the ear. Tympanic temperatures are consistently higher than cloacal temperatures.^{4,15}

Blood Pressure. Mean blood pressure can be monitored with a doppler and should remain above 100mmHg. Pressures are often difficult to measure in avian patients because of their small size. These are not usually measured in clinical practice.

Blood Gas. Blood gases measured by arterial samples are not practical for most practitioners and are not tolerated by the smaller avian patients. SaO₂ measurements using an oximeter can be used on the wing web, toe, tongue or the area over the tibiotarsal bone. The tibiotarsal area tends to give the most consistent and reliable readings.⁴

Anesthetic Complications and Emergencies

Complications. Regurgitation and aspiration can be a major complication if the patient has not been fasted or is suffering from crop impaction or stasis. Therefore, it is important to empty the crop before anesthesia and place an endotracheal tube.

Respiratory Arrest. Respiratory arrest may occur due to the depressant and muscle relaxing effects of anesthetic agents. If this was to occur, introduce fresh air in the endotracheal tube or lightly press and release on the chest to induce air intake. If the patient is not intubated then intubate or place an air sac tube. Remember that apnea will result while PaO₂ is high and PCO₂ is low. If spontaneous respiration does not occur in approximately three to five minutes, 5-10mg/kg of Doxapram may be given IM or IV. If the patient is on injectable anesthesia then give the reversal agent intravenously. Doxapram HCl may also be used on the tongue to stimulate respiration.⁴ Resuscitation and monitoring of the heart rate should continue until the bird is breathing on its own. Birds that have one episode should be rescheduled because a second and third episode usually results in cardiac arrest.⁹

Cardiac Arrest. If a bird goes into cardiac arrest it is usually fatal. Resuscitation efforts

are often unsuccessful. Norepinephrine may be given intracardiac to stimulate the heart but if this is not successful open heart massage is necessary at 60 or more compressions per minute. It is recommended by Harrison to use a saline-soaked cotton swab inserted through the thoracic air sac to do the compressions. Efforts should be continued for up to 5 minutes.⁹

Hemorrhage. Hemorrhage is another possible emergency with avian anesthesia and surgery. The amount of blood volume a bird has is approximately equal to 10% of their body weight and they can safely lose 1% of the body weight in blood. If during a surgical event the patient loses too much blood, it should be replaced with isotonic fluids or a blood transfusion. Surgical equipment such as electrocautery units are now available to help minimize the amount of blood loss.

Post-anesthetic Considerations

Recovery. Recovery should include delivery of 100% oxygen after the inhalant has been discontinued. Recovery should occur in a pre-heated environment such as an incubator. The time to complete recovery varies with the anesthetic agent used. Patients recovering from isoflurane are usually perching and ready to eat within an hour. Patients recovering from ketamine may experience some seizure-like activity, so it is best to keep the bird wrapped up in a towel to prevent wing flapping and self-inflicted trauma. Recovery from injectable anesthesia should be expected to be long and violent. Lights should be dimmed and noise kept to a minimum. Administration of a reversal agent may be required if recovery is taking too long. Regardless of the anesthetic protocol used, most birds will experience emergence delirium.⁷

Monitoring the patient until complete recovery is the best way to assure patient survival. The safest way to monitor post-anesthesia is to keep all monitoring devices on until the animal will not tolerate them anymore. Then the bird should be observed until it can perch on its own without difficulty.

Analgesia. Opioids are the most popular post-anesthetic analgesic drug used in avian practice. Clinical impressions have been the basis for the use of analgesics. The accepted dose for butorphanol is 3-4mg/kg. Butorphanol

causes a slight decrease in both heart rate and minute ventilation, but neither are significant. More studies and clinical trials are necessary to evaluate other analgesic possibilities.⁷

Conclusion

Avian anesthesia can be safely and successfully performed if the anesthetist is attentive and quick to respond in a situation. There are many opinions about how to successfully anesthetize a bird. Most people that regularly work with them recommend being prepared for the unexpected. For many people, experience has proven to be the best education. A poll of some anesthesia technicians resulted in the recommendations below.◆

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Rules for Successful Avian Anesthesia	
<div>1. Experience leads to competence.</div> <div>2. Concentrate on what you are doing.</div> <div>3. Technicians should give the case their undivided attention.</div> <div>4. Be thoroughly familiar with the equipment and drugs used.</div> <div>5. Anticipate emergencies! Have emergency drugs and equipment available.</div> <div>6. Know the health status of the patient. Maximize the health prior to anesthesia.</div> <div>7. Restrain bird quickly and efficiently to minimize stress. Do not induce a stressed bird, they are more prone to die under anesthesia.</div> <div>8. Monitor patient continuously.</div> <div>9. If uncertain of patient status, stop and check for sure.</div> <div>10. Keep patient warm. Hypothermia affects anesthesia levels.</div> <div>11. If air sacs are invaded anesthetic adjustments may be needed.</div> <div>12. Avoid prolonged "down-time;" lighten the patient quickly.¹³</div>	
Species Differences	<div>Macaws - harder to induce and more difficult to maintain at an adequate level of anesthesia.</div> <div>African Greys - go down screaming until they under anesthesia.</div> <div>Mynahs - crash quickly and often.</div> <div>Birds of prey - high risk of crashing. Apneic on induction.</div> <div>Cockatoos - more predictable and easier to maintain.</div> <div>Amazons - usually predictable. Fight till the last second.</div> <div>Sun Conures - intolerant of anesthesia.</div> <div>Cockatiels - do well under anesthesia.</div> <div>Budgerigars - hardy anesthesia candidates.¹³</div>